The Baltimore Longitudinal Study of Aging

& Older & Wiser

U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health

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Preface

"Older and Wiser" describes the Baltimore Longitudinal Study of Aging (BLSA), America's longest running scientific examination of human aging. Written as the BLSA passed its 30th anniversay, "Older and Wiser" tells the story of how Drs. Nathan W. Shock and William W. Peter struck a unique partnership between scientists and volunteer research participants, which has grown steadily in size and scope.

The objectives of the BLSA are to measure changes in biological and behavioral processes as people age, to relate these measures to one another, and to distinguish universal aging processes from those associated with disease and particular environmental effects.

Today there are nearly 1,000 men and women, ranging in age from their twenties to nineties, who return regularly to the National Institute on Aging's (NIA's) Nathan W. Shock Laboratories, Gerontology Research Center (GRC) in Baltimore, Maryland, and participate in more than 100 physiological and psychological assessments which are used to provide a scientific description of aging.

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BLSA consists of a series of overlapping longitudinal studies, fashioned in such a way that new projects can be related to ongoing, as well as previously completed ones. Major interventions or manipulations designed to change the participants' normal patterns of life are not employed in the BLSA, but many findings from the study generate questions about interventions which are evaluated with other groups.

The progress of the BLSA has been recorded in over 300 scientific publications and in the book, *Normal Human Aging*. "Older and Wiser" describes some of the major research themes and findings of the BLSA. It is based on writings as well as interviews with BLSA scientists and research participants. The scientific legacy of the BLSA extends beyond publications. It includes research training of over 200 young scientists and physicians, educational material for hundreds of newspapers and magazines, scores of radio and television shows, and lectures to thousands of students, senior adults, and health care professionals.

The BLSA reflects the commitment of the National Institute on Aging to understand the aging processes and to carry out research that will improve the quality of life for adults of all ages.

We hope you enjoy "Older and Wiser," which is dedicated to the partners in science—BLSA research participants, scientists and supporting staff—whose combined efforts form the basis for the story told.

Nathan W. Shock, Ph.D.
Scientist Emeritus, NIH

T. Franklin Williams, M.D.
Director, NIA

James L. Fozard, Ph.D.
Associate Scientific Director,
NIA, for the Baltimore
Longitudinal Study of Aging

Notes:

For a comprehensive scientific report of the first 23 years of BLSA studies, see *Normal Human Aging: The Baltimore Longitudinal Study of Aging* N. W. Shock, R. C. Greulich, R. Andres, D. Arenberg, P. T. Costa, Jr., E. G. Lakatta, and J. D. Tobin. U. S. Government Printing Office, Washington, D.C., NIH Publication No. 84-2450, November 1984, 399 pp.

Individuals interested in becoming BLSA participants, or scientists interested in collaborating in BLSA research should write to the Associate Scientific Director for the Baltimore Longitudinal Study of Aging, NIA Gerontology Research Center, 4940 Eastern Avenue, Baltimore, MD 21224, or call (301) 550-1766.

1 Older & Wiser

We are all students of aging. We carry with us private laboratories in which we observe the processes that occur as we grow older. Our personal observations are necessarily random, often colored by stereotypes, and may concentrate upon negative aspects. For example, many people tend to characterize age-associated changes merely as deterioration. They say:

"The eyes are going."
"I don't have as much stamina as I used to."
"I just can't concentrate anymore."

"The eyes are going."

"I don't have as much stamina as I used to."

"I just can't concentrate anymore."

In fact, when aging is studied scientifically, a very different portrait emerges. Vision, stamina, and the ability to concentrate may be altered only mildly over the years. And some capacities such as vocabulary may actually improve.

Societal stereotypes have risen, in part, because aging resists easy study methods. It occurs slowly, over decades, beginning with the end of adolescence and continuing throughout life. A comprehensive study of aging must look intently at that entire span.

Using the common scientific tool known as a *cross-sectional* study, researchers can compare a group of older persons with a group of younger persons and arrive at certain general conclusions. But much more can be learned by observing the aging process within the same group of people over an extended period of time. This is called a *longitudinal* study and, by definition, is an exhaustive, extended quest for knowledge. Longitudinal studies are, therefore, relatively rare.

In 1958, a group of farsighted researchers and volunteers began what many believe to be the most ambitious longitudinal study ever attempted. Its goal is to answer one encompassing question: What is normal human aging? Currently, nearly 100 investigators (a mixture of staff scientists, postdoctoral trainees and outside researchers) at the National Institute on Aging's N. W. Shock Laboratories, Gerontology Research Center, located on the grounds of Francis Scott Key Medical Center in east Baltimore, continue examining the basic biological, behavioral, and environmental factors which contribute to aging.

The longtiudinal approach provides a physiological profile of each individual in a group of people covering the entire adult age spectrum. Over time, measured changes in the profile provide information simply unavailable in a one-time, cross-sectional study. For example, researchers can determine whether the body systems in a given group of people age at the same or different rates. If so, why? Do the physiological characteristics of a group of 65-year-old men or women match those of a similar group measured a decade earlier? If not, are there identifiable environmental or biological explanations?

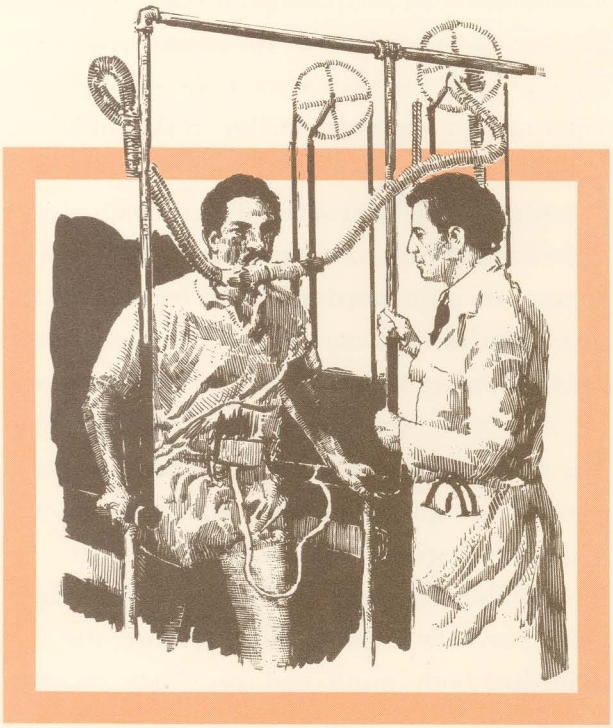
What is normal human aging?

The Baltimore Longitudinal Study of Aging may appropriately be called "the original myth-buster." In its first 30 years it has uncovered some answers to the basic question: What is normal human aging? Some answers have been surprising; some have provided scientific confirmation of popular, subjective beliefs. Myths have been shattered; hypotheses proven. For example, it was once thought that cardiac output invariably declined with aging. However, studies with the BLSA have shown that when older hearts are carefully screened and found free of disease, their cardiac output is comparable to that of younger people.

It was once thought that cardiac output invariably declined with aging.

Another example, in years past it was commonly believed that the older person's personality changed over time. He or she became crankier, or more mellow as they aged. This myth has not held up under close scrutiny by BLSA scientists. With aging, the human personality remains remarkably stable. An individual who is cheerful and optimistic when young usually remains so throughout life. On the other hand, someone who is unusually grouchy and mean in early life keeps the same personality traits in late life.

In years past it was commonly believed that the older person's personality changed over time.



A BLSA particpant, strides on a treadmill during a cardiac stress test.

But, in addition to myth-busting, the major story of the BLSA's first three decades is what we have learned about the quality, rather than the quantity of life. In other words, how well we age rather than the length of our lives.

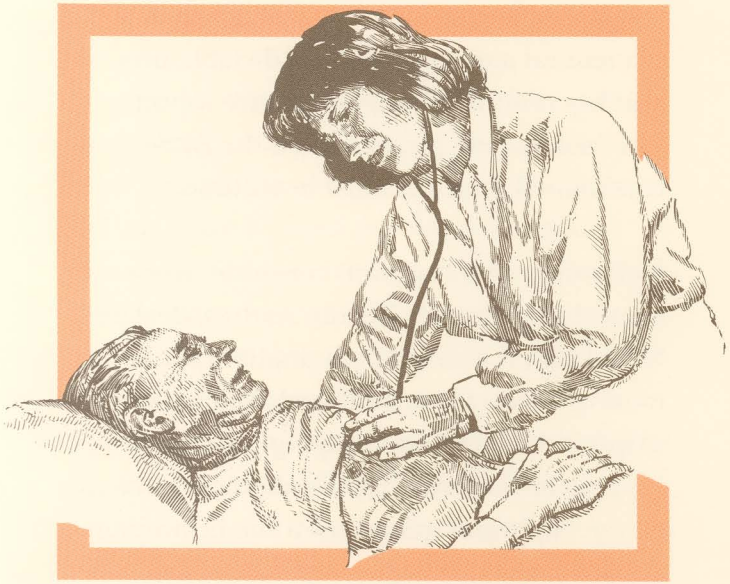
As a result of 30 years of study, BLSA researchers have reached two important conclusions 1) *Aging is not a disease*, and 2) *There is no single, simple pattern of aging.* To be sure, older people are more susceptible to a variety of diseases, but none of these diseases is brought on automatically by the passage of years. Take glucose (sugar) tolerance for example. In some people, the body's ability to metabolize sugar rapidly begins to decline in the mid-thirties. Even so, most people do not become diabetic in their later years. The individual differences in the way sugar is metabolized seem to be influenced markedly by body fat, maximum aerobic capacity, weight/height ratios, or other factors.

Aging is not a disease, and there is no single, simple pattern of aging.

It is true that some abilities decline, but some remain stable. Others actually improve.

The study has shown that aging does *not* necessitate a general decline in all physical and psychological functions. It is true that some abilities decline, but some remain stable. Others actually improve. Furthermore, the individual body, mind, and spirit show great

capacity for variability and adaptability. Researchers can declare that various changes may occur with age, or are likely to occur with age, but they cannot predict with certainty what changes *will* occur. The only sure thing is that individuals will age differently.



First time BLSA participant, Leonard M. Paisner, gets a physical examination from nurse practitioner Debbie Kramer.

Changes do occur with age, but they tend to occur gradually. Any unusual change in physical and/or psychological abilities is more likely to be due to disease than to age. The BLSA has helped to bring about better diagnostic practices by alerting physicians to this fact.

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The BLSA is a unique story in scientific research, partly for its broad contributions to our knowledge of aging, and partly for the promise of its future.

Nowadays, although many still fear or misunderstand the effects of aging, more and more people are beginning to understand that aging is a natural and somewhat predictable process that has positive as well as negative aspects. The information gleaned from the BLSA has contributed to this change in attitude.

As for when the study will conclude, NIA's clinical director, Dr. Reubin Andres, declares, "The BLSA is a *series* of longitudinal studies, most of which are interrelated. Many more surprises concerning the aging process are likely to be forthcoming. We did not think up all the important questions in the beginning. We are constantly beginning new studies within the BLSA. The questions never end, they just get more and more complex." Thus, Dr. Andres' standard answer to the question, when will the BLSA end? is, "As soon as Nature hath revealed all her secrets to us."

2 Origins

The Baltimore Longitudinal Study of Aging was the brainchild of two remarkable men. In 1958, Dr. William W. Peter, a retired officer of the U. S. Public Health Service and a medical missionary, decided to bequeath this body to science. To do so, he was referred to Dr. Nathan W. Shock, chief of the then Gerontology Branch (now GRC) in Baltimore. The two men met and, instead of bequeathing his body to science, Dr. Peter joined Dr. Shock to begin planning a unique research partnership.

The GRC was already 18 years old, having been established with the aid of a one year grant from the Josiah Macy, Jr. Foundation and thereafter funded by the National Institutes of Health. Dr. Shock joined the gerontology unit shortly after its creation and developed it into the largest institution in the western hemisphere devoted entirely to studies of aging.

By 1958 Dr. Shock had become convinced of the need to study community-dwelling people as they age, that is longitudinally. How else could he track the patterns of aging? He proposed this idea to Dr. Peter in blunt terms. Rather than studying individuals' bodies after their deaths, "We need live people," Dr. Shock later recalled saying. Dr. Peter was intrigued by this idea.

Together, the two men planned the most comprehensive and ambitious longitudinal study of aging ever attempted, one that would observe and document the physical, mental, and emotional effects of the aging process in healthy, active people.

As Dr. Shock positioned the scientific machinery, Dr. Peter began his personal quest to find a group of volunteers who would agree to come to the GRC for a few days periodically to be poked and prodded in the interest of scientific advancement. He preached his message to his relatives, neighbors, and the many government scientists and educators in his circle of friends. Dr. Peter reasoned that "People like ourselves, who are living independent lives in the community, should volunteer as subjects for the study of aging." The study was to be broad in scope, including both physiological and psychological changes that occur over time. It was to be a total volunteer effort. Participants would even have to arrange their travel to and from Baltimore. They were to be special, "healthy community-living" volunteers unlike hospital patients whose illness might mask normal age changes the scientists were seeking to define.

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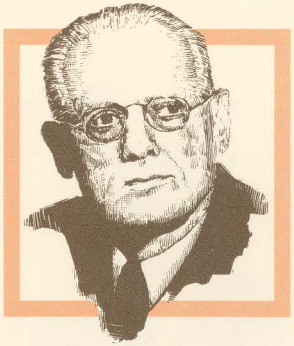


Dr. William W. Peter, the First Baltimore Longitudinal Study member; his efforts brought in hundreds of volunteers, including nearly a score of his relatives.

Dr. Peter organized a verbal "chain letter" campaign among the nucleus of early volunteers. Each recruit was asked to round up other recruits and so on, and by 1965, more than 650 volunteers had joined the study.

By 1958 Dr. Shock had become convinced of the need to study community-dwelling people as they age, that is longitudinally.

Dr. Nathan W. Shock, Founder of the BLSA and a leader in U.S. gerontology for nearly 50 years. Dr. Shock is now NIH Scientist Emeritus.

Ironically, Dr. Peter never lived to take part fully in the longitudinal part of the study. He insisted on being the first to undergo the initial physical examination. However, during that examination, doctors discovered an aneurism on his aorta. The aneurism was repaired successfully, but while in intensive care following surgery Dr. Peter died in 1959, never living to see the unique study he helped create become a reality.

For the next 30 years, GRC scientists conducted the tests, documented the results, and watched the BLSA generate interest in gerontology and its medical counterpart, geriatrics. Over the years, the BLSA expanded in scope and numbers. In 1975, it became a part of the newly established National Institute on Aging (NIA) under the umbrella of the National Institutes of Health.

Dr. Shock was 51 years old when the study began and he aged in tandem with it. In 1977 he stepped down from the post of scientific director of the NIA, but if he had learned anything about aging, it was that he was not ready to give up his work at the tender age of 70. He was named NIH scientist emeritus, which freed him from administrative duties and allowed him to concentrate upon writing articles on the history of gerontology, both in this country and internationally. He was once heard to say, "When I sit down at that desk, I know that's the place where I work. My rear end is geared to my cerebral cortex."

Dr. Shock still maintains that cerebral connection, writing and consulting with gerontologists all over the world. He is known as the grand "old man" of gerontology.

Jane Peter Coffin, eldest daughter of Dr. W. W. Peter.

3 Heroes

The quiet heroes and heroines of the BLSA are the some 1,800 men and women who have made a total of more than 11,000 visits to the GRC over the years. There currently are some 1,000 active volunteers. They come once every 2 years and willingly undergo 2-1/2 days of rigorous testing. Over 109 separate procedures are used to monitor the full range of each participant's physical and mental abilities. These include appraisals of heart and lung function, bone status, nutrition, the senses, and personality. Data collected are used in more than 50 ongoing studies.

The volunteers are paid nothing. They even pay their own travel expenses. Participants do receive a thorough medical evaluation, the results of which are transmitted back to their personal physicians. But, some of the tests are physically uncomfortable; others are tedious. Some require substantial mental and physical effort. Some of the questioning could be considered as rather personal. Tests of intellectual functions can be ego-threatening. Nevertheless, there has always been a long waiting list of eager volunteers.

Dr. James L. Fozard, associate scientific director for the BLSA, says "These people are real partners in science. Their commitment is a remarkable display of altruism."

Because the study of aging encompasses the entire adult lifespan, BLSA volunteers range in age from a few in their late teens to those in the mid-nineties. The only criterion for being accepted as a volunteer is that the person is in reasonably good health at the time she or he volunteers. While there are no social, educational or economic requirements at all for volunteers, in fact, most of the current participants are married; three-fourths of the men hold bachelor's degrees, nearly half hold master's degrees, and one-fourth have doctorates. Although their number of degrees are not quite as high, for the most part, the women in the study also are highly educated.

"These people are real partners in science. Their commitment is a remarkable display of altruism."

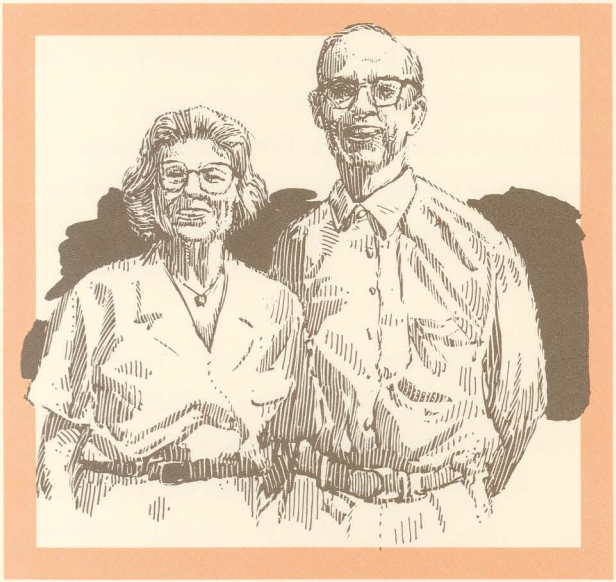
Participants tend to describe themselves as "financially comfortable." Their occupational, educational and economic status, general good health, high level of social adjustment, and interest in aging make them, in one sense, a homogeneous sample

but one that still displays a great deal of variability in any specific test. Even with such a homogeneous sample, BLSA researchers have found that the essential physiological and medical trends seen in the participants are representative of those found in many other diverse populations studied throughout the world.

The study's volunteer faces change gradually and systematically. Approximately 400 participants have died; a like number have dropped out, while 1,000 remain active in the BLSA. Inevitably some have moved so far away that it is difficult for them to return. Others have found continued participation difficult because of changed social conditions or illness. When women were added to the study in 1978, a special effort was made to recruit female relatives of current participants in order to trace significant genetic and environmental relationships. Dr. Eleanor Peter, widow of Dr. William W. Peter, was one of the first women enrolled.

Who are these men and women, and why are they willing to make this enormous sacrifice of their time and effort?

They are people like Jack and Mary Harvey of Rockville, Maryland. In 1963, one of Jack's coworkers at the U. S. Department of Transportation recruited him for the BLSA. "I've always been health conscious and



BLSA volunteers of long standing, Jack and Mary Harvey.

scientifically curious," he says. "I realized that I could make a worthwhile contribution." Jack is retired but remains an active BLSA participant.

Over the years Mary saw Jack periodically journey to Baltimore for what seemed to her like a "three day vacation." She readily joined the program in 1978 when women

were first recruited and found that, indeed it was a bit like a vacation. "They give you first-class treatment," she says. "For a housewife who is always taking care of others, it's great for a change."

As of this writing, Mary has completed her sixth visit as a BLSA participant. Jack, who has made 14 visits over the years, declares,"I realize that I've been in the program so long that I'm a very valuable test specimen."

4 The Aging Body

One of the most important findings of the BLSA is that the physical effects of aging are highly individualized.

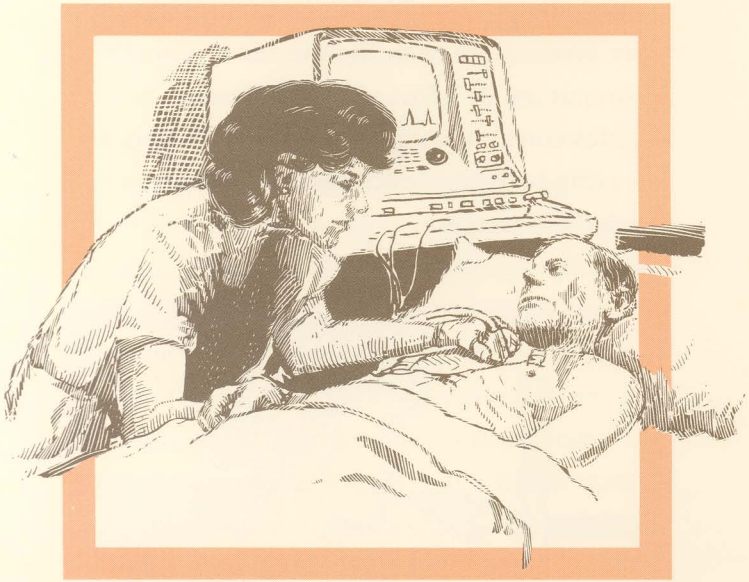
One of the most important findings of the BLSA is that the physical effects of aging are highly individualized. For example, an 80-year-old can be in better physical condition than his or her younger companions. BLSA results show quite clearly that calendar age by itself may be a poor predictor of physical performance.

Researchers must keep that caveat firmly in mind. The effects of aging can be tracked, on the average, but they will not necessarily apply to a specific individual. Working with those averages, researchers have learned much.

As one example, BLSA investigators noted from periodic chest x-rays that the heart grows slightly larger with age. Systolic blood pressure, while remaining within the normal range, also increases by about 15 percent between the ages of 35 and 70 years.

These may be adaptive changes—and in that sense normal, healthy and necessary phenomena. Although the older heart is unable to increase its pumping rate during exercise as much as a younger heart, it appears to compensate by dilating to a greater extent, delivering more blood per heartbeat. According to

Drs. Edward Lakatta and Jerome Fleg of the NIA's Laboratory of Cardiovascular Science, the healthy, exercising older heart increases its output in a somewhat different but just as efficient manner as the younger heart. In each decade of adult life, otherwise healthy

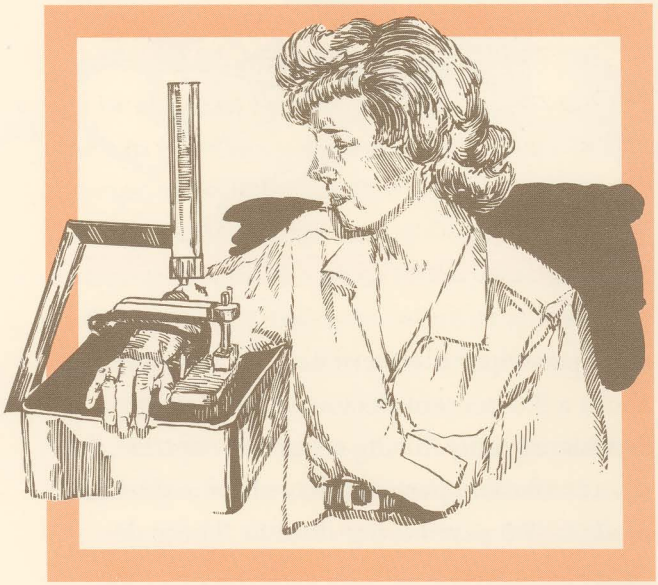


A Francis Scott Key technician administers an echocardiography test to a volunteer.

male participants experience, on average, about a 9.6 percent decline in maximum aerobic capacity during treadmill exercise, whereas female participants exhibit a decline of about 7.5 percent per decade. These declines in maximal aerobic capacity go along with the known age-related declines in maxi-

mal work performance. Major contributors to these decreases are the lower levels of physical activity and loss of muscle mass which usually accompany the aging process.

We know by simple observation that older people tend to shrink in height. This change due in part to alterations in bone structure, is more severe in women than in men, and is accompanied by a loss of muscle tissue. Muscles consume large amounts of oxygen. If the aging body has less muscle, it should require less oxygen.

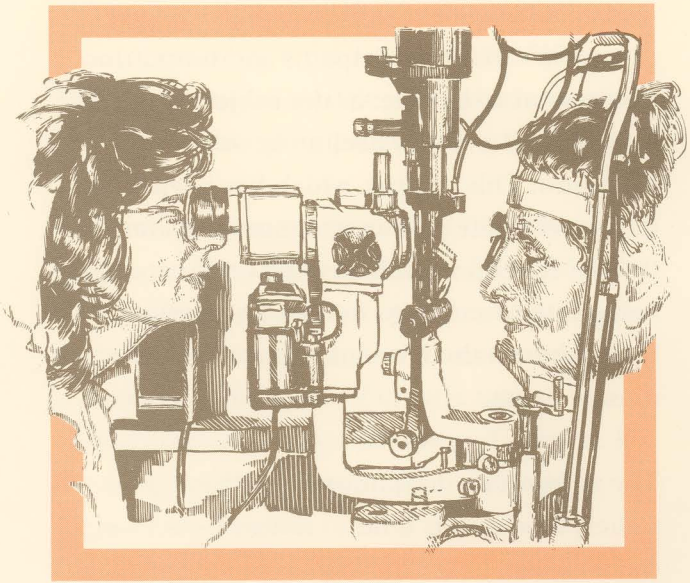


This single photon absorpiometer determines bone mineral changes in volunteer Deborah Coffin.

Researchers studied the oxygen consumption rate of 355 BLSA participants and found this assumption to be true: as the subjects aged they showed a steady decline in oxygen consumption. This decline, which has been misinterpreted in the past as evidence of decreased thyroid function, could now be understood as being due to a change in the composition of body tissues—the aforementioned loss of muscle tissue.

The aging body does not normally lose fat, rather, fat deposits tend to redistribute from the area just under the skin to deeper parts of the body. Scientists have observed that the slimmest BLSA subjects were not necessarily the healthiest. An analysis of many studies, including the BLSA, has shown that gross obesity is clearly unhealthy, but a weight gain of about a pound per year (providing that a person started off fairly slim in his or her twenties) appears to be associated with general good health and longevity.

This finding led to a proposed new series of tests in which BLSA subjects will be weighed underwater. The BLSA scientists believe this method will enable them to quantify more accurately the amount of fat in the body.



Slit lamp photography measures the density of cataract formation, if any, on the eye's lens of participants such as Margaret Ashelman. Here, the photographer is Dr. Sheila West.

Previous BLSA analyses have shown that fat may be the least healthy, i.e., making one more prone to conditions such as heart disease or diabetes, when it is concentrated around the waistline, and the least harmful when it is concentrated around the hips. The former is a tendency of men; the latter more characteristic of women.

As the human body ages, the change in tissue composition leads to a lower water content and this physiological finding has important clinical implications. Most drugs are distributed in the body by being dissolved in water, and with

less water in the body, lesser amounts of drugs are needed to achieve the proper concentration within body tissues. This BLSA finding is one of the factors that has helped sensitize physicians about the need to adjust drug dosage in older people.

Certain neurological tests have recently been added to the BLSA regimen, and the early results tend to debunk the myth that the nervous system degenerates greatly with age. On the average, older BLSA subjects appear to be nearly equal to their younger counterparts in their abilities to stand on one leg, walk a straight line, walk on their heels, gaze upward, and feel sensation in their hands. BLSA guest researcher, Dr. Claudia H. Kawas, a Johns Hopkins neurologist, has observed that in BLSA subjects, "By and large, the supposed neurological age changes simply are not there."

On the average, older BLSA subjects appear to be nearly equal to their younger counterparts in their abilities to stand on one leg, walk a straight line, walk on their heels, gaze upward, and feel sensation in their hands.

Diabetes is a disease that has long been associated with age. BLSA research has played an important role in altering the diagnostic standards used to interpret the glucose tolerance test. In the past, these standards were based upon the performance levels of young adults only. As a result, an unrealistically high

percentage of middle aged and, especially, older persons were being misdiagnosed as being diabetic.

William Bennett smiles bravely as a blood sample is taken for a glucose tolerance test given to most participants.

The decline in glucose tolerance that occurs with aging has now been shown in BLSA subjects to be due only partly to aging processes themselves—it is also caused by increasing fatness, by redistribution of body fat, and by physical inactivity.

The newer standards for the glucose tolerance test, which have been internationally accepted, have greatly reduced the number of "false-

positive" tests in older people. Research continues on this common disorder of aging in order to define with even greater accuracy the factors underlying the decline in glucose tolerance associated with aging. One of the most important research advances for the study of these factors is the development of the "glucose clamp technique" by Dr. Reubin Andres and his colleagues. The article describing that technique has become one of the most highly cited papers in the biomedical literature. BLSA subjects were among the earliest persons studied with this technique.

Measures of kidney function provide one of the best examples of the individuality of aging. On the average, kidney function decreases with age. But many individuals maintain adequate kidney function and a minority of participants even exhibited increased kidney function as they aged.

The average declines in sensory abilities, i.e., smell, taste, vision, and hearing, appear to confirm the common belief that they are associated with aging. But the explanations for these declines, if proven, may reveal them to be disease-caused.

Age does bring clear and documented decreases in smell and taste. As part of an overall dental and oral-sensory program of studies, Dr. Carolyn Tylenda, a National Institute of Dental Research collaborator, has administered a series of 40 scratch-and-sniff tests to BLSA participants. Although many subjects over the age of 65 continue to score perfectly, there is an average decline in the ability to discern smells, beginning about age 45 and increasing after age 65.

Dr. Tylenda's studies of the sense of taste show a similar pattern, but with even more diversity. In healthy subjects, the sense of taste does not necessarily decline with age, and if it does, that decline is likely to involve only one of the four taste qualities. Further, tests show the loss does not markedly effect a person's ability to appreciate food.

The sense of taste does not necessarily decline with age, and if it does, that decline is likely to involve only one of the four taste qualities.

Vision tends to decline with age. However, the ability to see fine detail changes little until one's seventies. BLSA researchers are attempting to learn why this occurs so that effective coping mechanisms can be developed. As Dr. Fozard explains, the loss of visual acuity over the years may be caused by less light reaching the retina, an increasing amount of cellular

The ability to see fine detail changes little until one's seventies.

debris in the aqueous fluid, as well as by degenerative changes in the visual nervous system.

On the other hand, there are certain eye changes which may be disease-related such as the apparent greater opacity of the eye's lens and greater degeneration of the macula (in the retina), but not necessarily associated with aging. Current research in the BLSA is attempting to assess each of these phenomena.

Harvey and Violet Everett review vision changes.

Hearing ability seems to decline, especially at higher frequencies. Hearing threshholds (the ability to hear faint tones) increase continuously over the lifespan according to BLSA studies. "There are a variety of possible causes," Dr. Fozard says, "but loss of hair cells in the cochlea is believed to be the main one."

Are there sexual changes that go along with aging? In men, at least, there appears to be a steady decline in sexual activity with age, although those who were more sexually active as young adults continue to exhibit a higher rate of sexual activity after age 40 compared with the group as a whole. It has long been postulated that a decline in male sexual vigor is due to a hormone deficiency, but this has not proven true. Most healthy older men in the study produce testosterone at levels comparable to younger men.

Aging seems to have little effect upon the quality of sexual pleasure in healthy women, although sexual desire and frequency of orgasm may decrease. Of 156 women interviewed about their sexual activities and attitudes, the majority said menopause had little effect on sexual satisfaction.

In general, the simpler functions of the human body deteriorate less than the more complex functions. For example, the speed at which nerves send their messages throughout the body decreases only mildly with age, perhaps because this function is performed totally within the neurological system. On the other hand, maximum breathing capacity decreases progressively with age in most people, perhaps because it requires coordination between the neurological and muscular systems.

In general, the simpler functions of the human body deteriorate less than the more complex functions.

Huffing and puffing is the chore for Margo Groff in this "popular" pulmonary test.

5 The Aging Mind

Mental performance, on the whole, remains strong at least to age 70. Then it declines, but not uniformly. Interestingly, one BLSA study showed that those men in their seventies who retain proficiency in problem-solving tend to live longer than those whose mental abilities have slipped. Evidence from other studies suggests that mental ability may be a more important determinant of longevity than physical ability. For example, one study found that individuals who, during their student years, had been elected to Phi Beta Kappa, the honorary scholastic fraternity, ultimately lived slightly longer than individuals who had lettered in athletics.

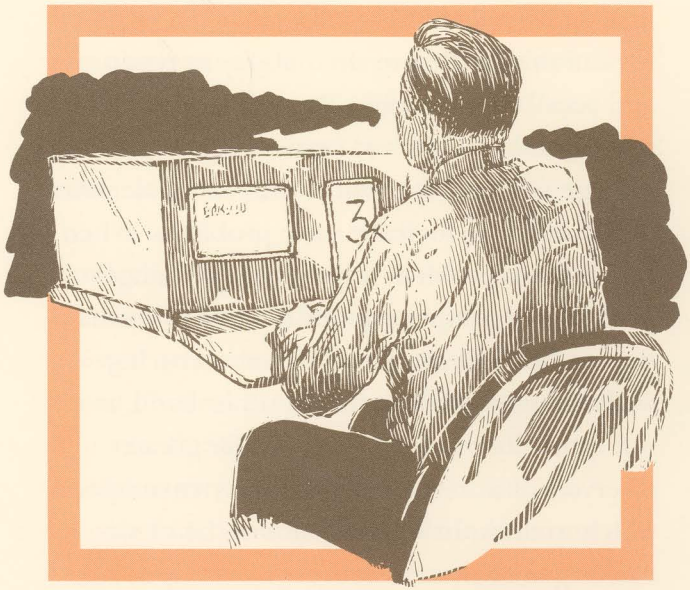
Mental performance, on the whole, remains strong at least to age 70.

Evidence from other studies suggests that mental ability may be a more important determinant of longevity than physical ability.

"Vigilance" describes a person's ability to respond to infrequent and unpredictable stimuli. To test for it, BLSA study subjects watched a mock-up of a wall clock for an hour and reported whenever the minute hand jumped two spaces instead of one. Sixty-five-year-old men are as vigilant—or more so—than young "whippersnappers." But after age 70 vigilance declines sharply in many people, as does the reaction time required to respond to the stimuli. This suggests that a reduction in the reactivity of the central nervous system is a true effect of aging, though it occurs at a later age than commonly thought.

Men in their seventies, on the average, show a measurable decline in their ability to retain and recall visual images. Regarding problem-solving ability, however, up until age 70, the average person experiences little or no decline in the ability to logically solve problems. When faced with a problem-solving task, a younger person may compensate for too little information or lack of experience by remembering well. An older person, on the other hand, may not remember as well, but has a far greater reservoir of information and experience upon which to draw. In some situations, he or she may organize those resources relatively more efficiently and thus solve problems as well—or better—than the younger person, although this has not been proven.

It is important to note that these average findings are subject to high rates of variability. More than one-fourth of the subjects tested (on a 6-year cycle) after the age of 70 showed no decline in memory function, and some individuals continue to perform well in many facets of cognitive ability as they move into their eighties.



A volunteer participates in a word recall and response time experiment.

Many studies have compared the memory capabilities of various age groups, but the BLSA has a unique opportunity to measure memory in the same individuals over a period of time. The results are mixed because memory is not a unitary thing. Some types of memory, but not all, decline with age.

6 The Aging Spirit

Each of us has a constellation of traits and dispositions which uniquely define the individual. These are with us for life and in their totality constitute much of what we call the human spirit.

Before the BLSA began to study and identify the characteristics of aging, crankiness, severe memory loss, and general disorientation were often dismissed as "signs of old age." But the BLSA helped show that physically and mentally healthy older people tend to be as happy or as cranky as younger people—no more or no less. Furthermore, the healthy older person remains aware of and involved in the environment of life.

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Research into the personality traits of BLSA volunteers confirms that people demonstrate a wide variety of personality types, and that they remain constant over the years. "No matter how you view it, the only consistent evidence points to stability of personality," declares Dr. Paul T. Costa, Jr., chief of the Laboratory of Personality and Cognition. "With age, adults as a group neither increase nor decrease noticeably in any of the major personality traits."

For example, one familiar stereotype contends that people become more conservative with age. The BLSA has tested for this using a questionnaire designed to evaluate a subject's "openness to new experiences." The results indicate that an individual's conservative or liberal outlook on life tends to remain steady across time.

Or consider the stereotype of the older person as a crochety, complaining hypochondriac. Dr. Costa and his laboratory colleague, Dr. Robert McCrae, have learned that hypochondria is associated with personality not age. An individual who goes through life excessively concerned about physical complaints is likely to be a cranky, self-obsessed older person. But an individual who maintains a balanced interest in physical care throughout his or her life is unlikely to spend later years camped out unnecessarily in a physician's waiting room. Thus, any marked change in personality such as when a previously happy individual becomes chronically cranky is not a sign of normal aging. It is more likely to be a symptom that warrants a medical evaluation.

Jane Coffin self-evaluates her health status on one of the many computerized personality or cognition tests used at the NIA Gerontology Research Center.

The duration of the human aging process extending over the adult lifespan, is highly beneficial to the individual, for it gives him or her time to adjust to changes occurring in the body, mind and daily living environment. It was the aging Winston Churchill who muttered that growing old was "better than the alternative" and millions of active aging individuals prove this every day. Although body and mind may exhibit some deterioration and a greater susceptibility to disease, what is frequently overlooked is that the healthy human spirit has the ability to compensate for certain age-associated shortcomings such as mild memory loss or limitations on physical mobility.

Dr. Costa concludes: "We need not worry that we will become crotchety with age or that only firm resignation can save us from despair and the fear of death. We need not anticipate increasing social isolation and emotional withdrawal from the world. There is no reason to think that our interests will atrophy or that our values and opinions will become increasingly rigid and conservative. We need not dread our future."

On balance, the clear and critical message of the BLSA is this: Live the years of your life with vigor and exuberance, and chances are you will enjoy your golden years.

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Far from being a disease, normal human aging may simply be nature's way of telling a person to slow down and smell the roses, appreciate the wonder of life, and bequeath to younger generations a legacy of maturity. Old age is also a time for new fulfillments, particularly involving the use and sharing of knowledge and experience that has accumulated over a lifetime.

7 Healthy Late Life

Research on aging has two goals: Adding life to years and years to life. For now, adding life to years is the first priority.

From its inception, the BLSA's primary concern has been the quest to separate specific diseases from aging processes, thereby gaining a better understanding of normal human aging. In turn, the information gained may well allow more people to successfully realize a fuller and healthier life.

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"It was a surprise to me what little impact aging, in the absence of disease, has on mortality," Dr. Shock reports. "As we discovered better methods to diagnose disease, we learned that aging by itself was not the demon. The things that get you are those darned diseases."

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Regarding the onset of fatal disease, researchers in the Gerontology Research Center's Clinical Immunology Section may have, quite serendipitously, come upon a discovery that has major implications. Studying blood samples drawn from BLSA volunteers at intervals of 2 years or less, they first noted that, for most, the number of lymphocytes (white blood cells) in the system does not appear to drop with age. However, for some participants a

definite drop in the lymphocyte count was noted between visits. These volunteers complained of no disease symptoms and rigorous BLSA testing uncovered no overt signs of disease. Yet, something had happened to cause a drop in the number of circulating lymphocytes.

Subsequent review of data on the participants with a lower lymphocyte count revealed a mortality rate significantly higher than for those whose lymphocyte count remained stable. However, the decline in lymphocyte counts did not predict any one cause of death such as cancer but rather were spread among the usual common causes of death.

"They have a medical problem and don't know it," observed Dr. William H. Adler, chief of the Clinical Immunology Section. "And the tests and physical examinations don't detect the problem either." Dr. Adler theorizes that a hidden disease process is somehow linked to a fall in the lymphocyte count, but the link is not known.

Nevertheless, there may be far-reaching clinical applications to this new knowledge. Dr. Adler points out, "Prevention and early detec-

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tion are the best ways physicians have to combat disease, and here is a signal that may provide a very early warning. Doctors routinely check the lymphocyte count of their patients, but they rarely look back into the files to compare it to previous counts. We are now encouraging them to do so. My hope is that we will be able to determine the link between illness and lymphocyte numbers and perhaps be able to diagnose problems earlier in their course."

Over the years, more than 400 deaths have occurred among BLSA participants and about 38 percent were due to cardiovascular disease, a rate comparable to that for the U.S. population as a whole. Even so, the life expectancy for BLSA volunteers is about 8 years longer than that for the general population.

With knowledge about nutrition-related risk factors for heart disease growing rapidly, more individuals are expected to take measures that will enable them to live longer, free of cardiac disease.

BLSA nutritionists and other researchers are monitoring the lifestyle changes observed over the past 30 years, searching for correlations

with the changing pattern of cardiovascular disease. Indeed, if we are what we eat, then we have changed dramatically over the last three decades. Each BLSA volunteer answers a questionnaire concerning his or her dietary habits, and is asked to keep a food diary for the entire week after the biennial visit to the BLSA. As society in general acquired better dietary habits, these were reflected in BLSA participants. In men, over the years, the average cholesterol intake has dropped from about 600 mg per day to about 375 mg per day; the ratio of fat to the total diet has dropped from 42 percent to 35 percent; intake of fiber has increased by about 50 percent; and carbohydrate intake has increased from 38 percent to 44 percent of total calories.

BLSA researchers also have uncovered evidence that recommended dietary advice correlates with longevity. The diets of men who died of heart disease contained less fiber and more saturated fat than the diets of men without heart diseases, according to Dr. Judith Hallfrisch of the Laboratory of Clinical Physiology. A similar study showed that men who developed colon polyps ate less carbohydrates and fiber and drank about twice as much alcohol as did men without colon polyps.

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Other studies are under way to examine the relationships between diet and hypertension, stroke, cataract formation, osteoporosis, and diabetes.

Understanding of cancer has increased tremendously in the past 30 years. Biomedical researchers have recently suggested that in the average person cells may develop into cancer many times. However, in virtually all instances, researchers theorize that the body's immune system destroys the cancer cell before it grows into a tumor. According to this theory, the cancer becomes a threat only when it circumvents the immune system. BLSA studies show that as a person grows older his or her immune system exhibits a decreased ability of the T-cell component, and it is this component that has the ability to destroy tumor cells.

It has never been the BLSA's goal to find a "magic elixir" that would extend the human life span beyond its present range.

The decline in T-cell function begins at about age 40, which does correlate with an increased cancer risk. But, researchers do not yet know why there is a decline in immunity with age, or how to treat it.

It has never been the BLSA's goal to find a "magic elixir" that would extend the human life span beyond its present range. In recent

years, a number of theories and hypotheses concerning "life extension" have been put forth. However, BLSA scientists are not investigating current fad theories of life extension. The path they and their BLSA participant partners continue to follow is generating information that will enable men and women to reach "old age" with a minimum amount of difficulties or disabilities.

A recent car bumper sticker carries this motto: "I don't want to grow old, I want to grow older." For the BLSA, the slogan might read: "I don't want to grow old, only older and wiser." Even though the study is beginning its fourth decade, the work is not done. The BLSA's findings will continue to change the definition of aging.

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